DOCUMENT RESUME

ED 354 852 HE 026 275

AUTHOR Zwick, Rebecca
TITLE Differences in Graduate School Attainment Patterns across Academic Programs and Demographic Groups. A Research Report of the Minority Graduate Education Project.
INSTITUTION Educational Testing Service, Princeton, N.J.; Graduate Record Examinations Board, Princeton, N.J.
PUB DATE 91
NOTE 21p.
AVAILABLE FROM Educational Testing Service, Princeton, NJ 08541.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Academic Achievement; *Academic Persistence; Asian Americans; Blacks; *Doctoral Degrees; Enrollment; Foreign Students; Graduate Students; *Graduate Study; Higher Education; Hispanic Americans; *Minority Groups; School Holding Power; *Sex Differences; Universities; Whites

ABSTRACT

To identify differences in doctoral student achievement across programs, demographic groups and gender, the graduate careers of nearly 5,000 doctoral students from 11 departments at each of 3 major universities were investigated. Three types of data analysis examined numbers of students entering each department and the proportions of various groups, patterns of attainment of graduate school milestones, and association between attainment of milestones and potential explanatory variables. Minorities and women were found to be under-represented in graduate school and to have generally lower Ph.D. candidacy and graduation rates than their white and male counterparts. In two of the three schools, foreign students had higher candidacy and graduation rates than did white Americans. Also, in two of the three schools, the percentage of foreign students has increased substantially in recent years. A more general finding was that the doctoral candidacy and graduation rates in the 8 years following matriculation were higher in quantitatively oriented departments than in the humanities and social sciences. In general, undergraduate grades and Graduate Record Examinations scores had only a minimal association with the attainment of candidacy and graduation. Among these academically select students, nonacademic factors may play a crucial role in determining who ultimately attains the doctoral degree. Includes 34 references. (JB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED354852

Differences in Graduate School Attainment Patterns Across Academic Programs and Demographic Groups

Rebecca Zwick

HE 026 275

"PERMISSION TO REPRODUCE THIS MATERIAL IN **OTHER THAN PAPER COPY** HAS BEEN GRANTED BY

ETS

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

MGE

A research report of the Minority Graduate Education (MGE) Project, jointly sponsored by the Graduate Record Examinations Board and Educational Testing Service.

BEST COPY AVAILABLE

Copyright © 1991 by Educational Testing Service. All rights reserved.
Educational Testing Service, *ETS*, (ETS), and *GRE* are registered trademarks of Educational Testing Service.
Educational Testing Service is an Equal Opportunity/Affirmative Action Employer.

DIFFERENCES IN GRADUATE SCHOOL ATTAINMENT PATTERNS ACROSS ACADEMIC PROGRAMS AND DEMOGRAPHIC GROUPS

by
Rebecca Zwick

ACKNOWLEDGMENTS

This project is part of the Minority Graduate Education research agenda, jointly sponsored by Educational Testing Service (ETS) and the Graduate Record Examinations (GRE) Board. I am grateful for their sponsorship. I also wish to express my appreciation to the administration and staff of the participating schools. In addition, I would like to thank Ka-Ling Chan, Thomas Florek, Jo-Ling Liang, Dorothy Thayer, and Minhwei Wang for statistical programming and data analysis; Kate Pashley and Ira Sample for preparing the figures that appear in the report; Henry Braun for providing consultation on the survival analyses and reviewing the report; and Foster Schoenthaler for sharing his expertise on the GRE data base. Finally, I would like to thank Peg Goertz, Charlotte Kuh, Toni Clewell, and the GRE Research Committee for their helpful comments and Debbie Kline for her expert editorial assistance.

ABSTRACT

The graduate careers of nearly 5,000 Ph.D.-seeking students from 11 departments in each of three major universities were investigated, with a special focus on minority students. Minorities and women were found to be under-represented in graduate school and to have generally lower candidacy and graduation rates than their White and male counterparts. In two of the three schools, foreign students had higher candidacy and graduation rates than did White Americans. Also, in two of the three schools, the percentage of foreign students increased substantially in recent years.

A more general finding was that the candidacy and graduation rates in the eight years following matriculation were higher in quantitatively oriented departments than in the humanities and social sciences. In general, undergraduate grades and Graduate Record Examinations scores had only a minimal association with the attainment of candidacy and graduation. Among these academically select students, nonacademic factors may play a crucial role in determining who ultimately attains the doctoral degree.

INTRODUCTION

In recent years, the status of graduate education in the United States has received much attention in the popular press, as well as in educational journals. Studies show that American students represent a decreasing percentage of students earning doctorates in U.S. graduate schools, particularly in the sciences and engineering (ACE, 1987; National Research Council, 1986; Thomas, 1987; Trent & Copeland, 1987). Another disturbing trend is the decrease in the participation of Black American students in graduate education during the last decade (ACE, 1987; ACE/ECS, 1988; Blackwell, 1987; Brown, 1987; Mooney, 1989; Trent & Copeland, 1987). Some educators have expressed concern that talented undergraduates may be choosing to go to professional schools or may be entering the work force immediately upon graduation (Brademas, 1984; Hartnett, 1987), and that this may be particularly true for minority students (Mooney, 1989; Pruitt & Isaac, 1985). The under-representation of women in graduate education continues to be a major concern as well (Chamberlain, 1988). These phenomena have major implications for the role of minorities and women in university faculties and in the American work force in general.

To effect changes in the current system of graduate education, it is necessary to understand what happens to individuals who do enroll in graduate school. At what pace do these students reach milestones in their graduate careers, such as advancement to Ph.D. candidacy and completion of the doctoral degree? Can standard pre-admissions measures, such as test scores and undergraduate grades, be used to distinguish graduate students who complete the doctorate from those who do not? How do patterns of achievement differ across academic programs, universities, and demographic groups? Answers to these questions can be useful to graduate school administrators in allocating resources and improving educational policies that affect admissions and retention.

Using data on graduate students at Northwestern University, Zwick and Braun (1988) investigated these questions, focusing on 14 departments. The present study extends the work of Zwick and Braun (1988) in two ways. First, the new study includes data from three institutions. This aspect of the research serves to provide information about the generalizability of the Zwick and Braun findings and about the feasibility of multi-institution research on graduate education. The second way in which the present study differs from the previous one is that it includes more extensive analyses of graduate school careers for Black, White, and foreign students and for men and women, and, unlike the Zwick and Braun study, includes some analyses based on Asian and Hispanic students.

The analyses for this project were designed to meet two principal objectives:

1. One goal of the present study was to determine how the patterns of attainment of Ph.D. candidacy and the Ph.D. degree differ across departments and across institutions. How large is the variability across institutions in patterns of degree attainment compared to the variability among departments within a single school? To what degree is the attainment of candidacy and of the Ph.D. degree predicted by Graduate Record Examinations (GRE) scores and undergraduate grade-point average (UGPA)? Does the association of candidacy attainment and degree completion with these pre-admissions measures differ across departments and institutions?

2. Another major purpose of the study was to explore in detail the graduate careers of Asian, Black, and Hispanic students who are United States citizens. As a first step, an examination was made of the demographic composition of Ph.D. seekers who entered any of 11 departments at the three institutions during the years 1978 through 1985. Then, an analysis of the patterns of candidacy and degree attainment for minority students was conducted in selected clusters of departments. The attainment patterns of these students were compared to those for White and foreign students. The achievement of candidacy and the Ph.D. degree was also examined separately for men and women. Finally, the association of pre-admissions measures of academic skills with candidacy and graduation was examined within demographic groups.

A more comprehensive description of the research appears in Zwick (in press). The present report omits much of the technical detail and focuses on the findings about minority students.

School Contacts

Between March 1987 and December 1987, 20 universities were contacted to determine whether they maintained data bases that would lend themselves to the planned analyses and whether they would be willing to participate in the study. Three large research universities ultimately agreed to participate. Refusals were, in most cases, due to the unavailability of required data. The three participating schools requested that they not be identified in research reports and are therefore referred to only as Schools 1, 2, and 3.

Selection of Students for Study

In determining which entry cohorts and departments to include in the analyses, the primary consideration was that comparable data be available for all three schools. Data from Ph.D.-seeking students who entered during the period beginning in the fall of 1978 and ending in the fall of 1985 were included in the analyses; these were the entry cohorts for which all three schools provided data.

It was important to select departments that were similarly defined in all three schools and that had adequate numbers of students for analysis. These criteria led to the choice of the following 11 departments: Chemistry, English, History, Mathematics, Political Science, Psychology, Economics, Philosophy, Physics, Computer Science, and Sociology. In Phase 2 of the analyses, which focused on ethnic and gender groups, departments were grouped for analyses, as described in a later section.

Linking of School 1 Records to GRE Files to Obtain GRE Scores

For the years prior to 1982, the data base from School 1 did not include GRE scores. Therefore, with the university's permission, records from School 1 were linked to the GRE data base at ETS to obtain the scores for students in the departments selected for study. The linking process also provided the opportunity to acquire some information on UGPA (not included in the School 1 data base) and on ethnicity, based on responses to background items administered along with the GRE. Of the 2,913 School 1 students in this study, the GRE data base was the source of GRE scores for 1,479, self-reported UGPA data for 2,073, and ethnicity data for 127.

Coding of Ethnicity

Encoding student ethnic status in a manner that was consistent across schools was important in this study. The mapping of the information provided by the three schools and by the GRE data base into the seven categories used in this study is detailed in Table 1. The need for consistency and for adequate sample sizes necessitated the use of a classification system that was, in some cases, less refined than those used by the participating schools. For example, it was not possible to conduct separate analyses for Puerto Rican and Chicano students or for Chinese and Japanese students. The ethnic categories used in this study were Asian, Black, Hispanic, and White. These codes were applied to U.S. citizens only; foreign students constituted a separate category. Students who were neither Asian, Black, Hispanic, White, nor foreign were given a code of "other"; students for whom information was unavailable were placed in a "missing" category. As described above, missing ethnic information for School 1 students was in some instances filled in from the GRE data base.

Overview

The data analyses conducted for this study were of three basic types. First, descriptive analyses were conducted, showing the numbers of students entering each of the 11 departments and the proportions of women, minority group members, and foreign students. The second category of analyses involved the examination of patterns of attainment of graduate school milestones for each department and for demographic groups within clusters of departments. The final type of analysis involved investigation of the association between attainment of milestones and potential explanatory variables.

Table 1. Scheme for Encoding Ethnic and Citizenship Data[a]: Categories from Schools and GRE Data Base

Analysis Category	School 1	GRE Data Base[b]	School 2	School 3
Asian	Chinese Japanese Korean Polynesian Vietnamese/Other Asian	Oriental/Asian American	Oriental/Asian American	Oriental
Black	Black	Black/Afro-American	Black/Afro-American	Black
Hispanic	Chicano Other Spanish	Mexican-American/ Chicano Puerto Rican Other Hispanic or Latin American	Mexican-American/ Chicano Puerto Rican (Mainland) Puerto Rican (Commonwealth)	Hispanic Mexican-American/ Chicano Puerto Rican
White	White	White	White/Caucasian	White
Other	American Indian East Indian/Pakistani Filipino Other	American Indian/Eskimo Aleut Other	American Indian/Alaskan Native Other	American Indian
Foreign	[c]	[c]	Foreign	[c]
Missing	Decline to state [Blank]	[Blank]	Decline to state [Blank]	[Blank]

[a] The ethnic descriptions in the body of the table are those used by the data sources. Note that the GRE program no longer uses the designation "Oriental."

[b] Information from the GRE data base was used for some School 1 students who were missing ethnic data.

[c] Students were classified as foreign based on a citizenship variable.

Descriptive Analyses

As a first step in analyzing the data, the demographic makeup of the 11 departments was investigated. Results were tabulated separately for two cohorts of students, each corresponding to roughly half of the matriculation period included in this study. The first cohort consisted of students who entered during the period beginning in the fall of 1978 and ending in the summer of 1981; the second cohort consisted of students with entry dates during the period beginning in the fall of 1981 and ending in the fall of 1985.

Table 2 provides information about the percentages of ethnic and gender groups for the three schools and the two cohorts, combined across the 11 departments. Results for each department are given in Zwick (in press).

Ethnicity Results

In terms of ethnicity, the three schools showed similar patterns for Cohort 1: 72 to 75 percent of the students were White and 18 to 20 percent were foreign. The percentages of students who were Asian Americans, Black Americans, and Hispanic Americans summed to only 5 to 7 percent.[1] In Cohort 2, the School 1 results remained virtually unchanged, while at Schools 2 and 3, the percentage of White students decreased by roughly 10 and the percentage of foreign students increased by about the same amount.

The ethnic group results for individual departments (not shown) showed that the most typical pattern of change was a decrease in the percentage of White students and a corresponding

[1] The figures in Table 2 have been rounded to the nearest percent. The discussion here is based on a more precise set of results.

increase in the percentage of foreign students. This pattern occurred in most departments at Schools 2 and 3 and was also evident in the Computer Science and Sociology departments at School 1. Significant exceptions to this pattern occurred in the Political Science and Philosophy departments at School 1 and the English, History, and Sociology departments at School 3. In these departments, the percentage of White students increased and the percentages of foreign or Black students decreased.

Table 2. Percentages[a] of Ethnic and Gender Groups for Two Cohorts[b] in Three Schools

	School 1		School 2		School 3	
	Cohort 1	Cohort 2	Cohort 1	Cohort 2	Cohort 1	Cohort 2
Sample Size	1,058	1,855	210	423	423	668
Ethnic Group						
Asian	3	4	1	2	1	2
Black	2	1	2	0	3	2
Hispanic	2	3	1	1	1	1
White	72	71	75	63	73	64
Other	2	1	0	0	0	0
Foreign	18	19	19	31	20	31
Missing	1	1	1	2	1	0
Gender Group						
Male	74	72	72	65	72	73
Female	26	28	28	35	28	27

[a]Percentages may not add to 100 because of rounding.

[b]Cohort 1 includes entry dates of fall 1978 through summer 1981. Cohort 2 includes entry dates of fall 1981 through fall 1985.

The scarcity of Asian, Black, and Hispanic American students in the study is one of the most striking aspects of the results. Only rarely did any one of these groups comprise more than 5 percent of the students in a particular department within a cohort. The percentage of Asian Americans exceeded five at School 1 in the Chemistry and English departments in Cohort 1 and in the Psychology, Philosophy, and Computer Science departments in Cohort 2 and in the School 2 Political Science department in Cohort 1 (one student). The percentage of Black students exceeded five in the School 1 Sociology department in Cohort 2 and the School 3 Sociology department in Cohort 1, in the School 2 Political Science department in Cohort 1 and the School 3 Political Science department in Cohorts 1 and 2, in the School 2 History department in Cohort 1 (one student) and the School 3 History department in Cohorts 1 and 2, in the School 3 English department in Cohort 1, and in the School 1 Psychology department in Cohort 1. The percentage of Hispanic Americans was greater than five for Cohorts 1 and 2 in the School 1 Sociology department, in Cohort 1 in the School 3 Sociology department, and in Cohort 1 in the School 2 Mathematics department (one student).

Gender Results

The proportions of men and women in graduate school are also worthy of examination. Based on the gender results for the combined departments (Table 2), the percentage of male students was remarkably consistent, ranging from 72 to 74 percent, except for Cohort 2 at School 2, where the percentage of men dropped to 65 percent. A separate analysis (not shown) revealed that, combined across cohorts, the percentage of males at each of the three schools was highest for foreign students, followed in order by Asian, White, Hispanic, and Black students.

Considering the data from all three schools, the most heavily male departments were Mathematics, Physics, and Computer Science, all of which were typically at least 80 percent male. The departments that came closest to having equal numbers of men and women were English, History, Psychology, and Sociology.

Patterns of Attainment of Graduate School Milestones

For purposes of monitoring academic programs and for making projections about the U.S. work force, it is useful to examine rates of graduation for students in different universities, academic programs, and demographic groups. Investigating the attainment of candidacy can also be informative: How likely is it that students will attain this first milestone?

One complicating factor in analyses of this kind is that requirements for candidacy and graduation differ across universities, and, in some cases, across academic programs within universities. In addition to differences in documented policies, there may be less formalized differences in the ways in which schools or departments implement certain policies. Variations in policy across schools and departments undoubtedly had an impact on the analyses conducted for this project. It is important, therefore, to regard the patterns of attainment of graduate school milestones as functions of academic policies, as well as of student characteristics.

Survival Analysis

A detailed picture of the rates of attainment of candidacy and graduation at multiple time points can be achieved through survival analysis, a statistical method used to model the time until the occurrence of some event. Although survival analysis has its origins in medical research, where the events of interest are typically the deaths of individuals, the method has recently gained popularity in other fields. Two examples from the field of education are an analysis of Ph.D. attainment at Stanford University (Mathematical Methods in Educational Research, 1983) and an analysis of teachers' career patterns in Michigan public schools (Murnane, Singer, & Willett, 1988). The survival analysis methods used here, which were developed by Braun (1985; Braun & Zwick, 1989), are discussed further in Zwick (in press). In this study, survival analysis is used to estimate the

percentages of students who have attained candidacy or completed the doctoral degree for each of the eight years following entry into graduate school.[2]

To facilitate interpretation, survival analysis results in this report are summarized in Tables 3 - 8, in terms of the percentages of students who are estimated to have attained candidacy or graduated as of certain time points. For the graduation analyses based on ethnic groups, graphs of survival analysis results are also included (Figures 1 - 6). The vertical axis of these graphs represents the estimated percentage of students who have graduated; the horizontal axis represents the number of years since entering graduate school.

Two major categories of survival analyses were conducted. The first category involved comparisons of attainment patterns for the 11 departments in the three schools. The second major category examined attainment patterns for ethnic and gender groups. Within each of these analysis categories, survival analyses were conducted for two events: the achievement of candidacy and the completion of the Ph.D. degree. A preliminary analysis indicated that the means, variances, and intercorrelations of key variables were similar for the two cohorts. Therefore, in order to achieve greater stability of estimation, students from both cohorts were combined for the survival analyses.

Analyses Based on the 11 Departments

Tables 3 and 4 give the results of the survival analyses for the 11 selected departments, which have been grouped for purposes of display and discussion. Group I consists of four quantitatively oriented departments: Chemistry, Physics, Mathematics, and Computer Science. Group II consists of three humanities departments: English, Philosophy, and History. Group III includes four social science departments: Psychology, Political Science, Sociology, and Economics. Sample sizes for the 11 departments in the three schools ranged from 22 to 648.

Candidacy Analysis. Table 3 shows the estimated percentage of students achieving Ph.D. candidacy five and eight years after entry for the 11 departments in the three schools.[3] Five years after entry, School 1 and School 3 students were nearly always more likely to have achieved candidacy than School 2 students; results at eight years show that the School 1 students were, in general, most likely to have achieved candidacy, followed in order by School 3 and School 2 students. Survival curves (not shown) tended to level off by year 5 at School 2 and by year 4 at School 3, indicating that if candidacy was not reached by these years, it was unlikely to be attained. Only at School 1 were at least 50 percent of students in all 11 departments estimated to have achieved candidacy by year 8.

Table 3. Estimated Percentage of Students Achieving Ph.D. Candidacy by Department[a]

	Five Years After Entry			Eight Years After Entry		
	School 1	School 2	School 3	School 1	School 2	School 3
Group I						
Chemistry	70	63	73	71	63	73
Physics	56	45	53	81	49	54
Mathematics	61	49	69	64	51	70
Computer Science	56	36	44	69	44	48
Group II						
English	47	42	46	60	49	48
Philosophy	45	29	38	50	30	39
History	54	50	53	62	50	53
Group III						
Psychology	61	62	56	78	62	59
Political Science	56	45	53	64	47	54
Sociology	43	38	51	68	49	57
Economics	46	34	50	67	41	52

[a]Estimates of candidacy and graduation rates are based on slightly different groups of students.

Group I departments were somewhat more diverse than the other two groups of departments, but within this group, Chemistry generally showed the highest candidacy rates, while Computer Science usually showed the lowest. In Group II, History consistently showed the highest candidacy rates, followed in order by English and Philosophy. In Group III, Psychology had the highest candidacy rates at both five and eight years in all three schools. Political Science had the second highest rates at all three schools at five years; Sociology consistently had the second highest rates at eight years. In general, Group I departments had the highest candidacy rates, followed in order by Groups III and II.

Graduation Analysis. Table 4 shows the estimated percentage of students completing the Ph.D. five and eight years after entry for the 11 departments in the three schools.[4] The results show that School 3 had the highest graduation rates in every department five years after entry, whereas School 1 nearly always had the highest rates at eight years. In about half the departments at School 1 and most departments at the two other schools, the estimated percentage of students graduating by year 8 was less than 50.

In general, the results in Table 4 revealed more similarities within disciplines than within schools. Group I and Group III departments were typically more diverse than Group II. Within Group I, Chemistry always showed the highest graduation rates. Graduation rates were very similar for the three departments in Group II. In Group III, Psychology always had the highest graduation rates, followed by Economics. (Economics and Political Science had identical rates at year 5 at School 2.) In general, Group I departments had the highest graduation rates, followed by Group III and then Group II, paralleling the ordering observed for the candidacy analysis.

[2]Note that, for purposes of the analyses in this study, students who left graduate school without attaining candidacy or completing the doctorate were indistinguishable from those who have not attained these milestones because they were still working on them. Roughly speaking, these analyses focused on the probabilities of attaining candidacy or completing the doctorate x years after entering school, where x can take on the values 1 through 8. Also, note that analyses of candidacy and graduation rates were based on slightly different groups of students. Therefore, the reported results cannot provide accurate estimates of the proportions of students who attained candidacy but did not graduate as of a certain time point.

[3]Five-year values were chosen for tabulation because, in many of the survival analyses, differences across student groups first became apparent at this point. Eight-year values were tabled because this is the latest time point for which survival estimates could be obtained.

[4]This study focuses on the elapsed time between entering graduate school and attaining the Ph.D. Other studies focus on the elapsed time between the baccalaureate and the doctorate or on the amount of registered time in graduate school.

Table 4. Estimated Percentage of Students Completing Ph.D. Degrees by Department[a]

	Five Years After Entry			Eight Years After Entry		
	School 1	School 2	School 3	School 1	School 2	School 3
Group I						
Chemistry	33	30	47	82	64	77
Physics	7	10	19	73	49	53
Mathematics	20	18	36	51	30	52
Computer Science	20	14	32	63	32	46
Group II						
English	1	6	13	31	23	22
Philosophy	0	1	7	38	14	15
History	3	4	14	33	14	20
Group III						
Psychology	12	17	29	65	50	55
Political Science	2	5	16	34	13	26
Sociology	2	4	16	31	15	31
Economics	8	5	23	56	26	47

[a]Estimates of candidacy and graduation rates are based on slightly different groups of students.

Analyses for Ethnic and Gender Groups in Department Clusters

Because of the small number of minority students, comparisons of attainment patterns for ethnic groups within individual departments could not be conducted. Instead, for purposes of conducting survival analyses for ethnic and gender groups, departments that had similar survival curves in the 11-department analyses were combined to form clusters. The results of the 11-department analyses of candidacy and graduation were examined, focusing on years five and eight (see Tables 3 and 4) in order to find groups of departments with survival curves that were close together in both analyses in all three schools. Two departmental clusters were derived that met this criterion reasonably well: Cluster 1, which includes Mathematics, Physics, Computer Science, Economics, and Psychology, and Cluster 2, which includes Philosophy, History, English, Sociology, and Political Science. Chemistry did not fit well in either cluster and was therefore excluded from the ethnic and gender group analyses. Except for Psychology, it is clear that the departments in Cluster 1 are quantitatively oriented departments. Although it may seem odd that Psychology fell into this group, a similar finding was obtained in a survival analysis conducted at Stanford University (Mathematical Methods in Education, 1983), in which Psychology was found to group naturally with Chemistry and Physics. The second departmental cluster includes both social science and humanities departments.

At each school, survival analysis results were obtained within each cluster for men and women and for ethnic groups with sufficiently large samples. At School 1, results were obtained for Asian, Black, Hispanic, White, and foreign students; at School 2, results were obtained for White and foreign students only; and at School 3, results were obtained for Black, White, and foreign students.

Sample sizes for the ethnic group analyses ranged from 170 to 839 for White students, from 30 to 361 for foreign students, and from 7 to 43 for Asian, Black, and Hispanic students. Because of small sample sizes, results for Asian, Black, and Hispanic students, in general, and for foreign students in Cluster 2 at School 2 are not as well determined as those for the larger groups in the analysis. (In particular, the number of Black students in Cluster 1 at School 3 was only seven.) Sample sizes for the gender group analyses ranged from 78 to 384 for women and from 129 to 1,044 for men. Because of sample size limitations, results were not obtained for men and women within ethnic categories.

Ethnic Groups - Candidacy. Estimated percentages of students receiving candidacy five and eight years after entry are given in Table 5 for each of the included ethnic groups in Clusters 1 and 2 at the three schools. The candidacy rates for Clusters 1 and 2 in School 1 and School 3 (as well as the survival curves, which are not shown) reveal a strikingly similar pattern: In each case, foreign students had consistently higher candidacy rates than White American students, who, in turn, had higher rates than Black Americans. (As noted above, in Cluster 1 at School 3, the results for Black students are based on only seven students.) At School 1, Asian Americans had candidacy rates between those of White and Black students; Hispanic students had the lowest rates. The results at School 2 were somewhat different: In Cluster 1, the quantitative group of departments, White and foreign students had nearly identical rates, whereas in Cluster 2, White Americans had higher candidacy rates than foreign students.

Ethnic Groups - Graduation. Estimated percentages of students completing Ph.D. degrees five and eight years after entry are given in Table 6 for each of the included ethnic groups in Clusters 1 and 2 at the three schools. In addition, plotted survival curves for these analyses are given in Figures 1 - 6. Within each school, results are graphed separately for Clusters 1 and 2. As noted earlier, the vertical axis of these graphs represents the estimated percentage of students who have graduated; the horizontal axis represents the number of years since entering graduate school.

Table 5. Estimated Percentage of Students Achieving Ph.D. Candidacy by Ethnic Group[a]

	Five Years After Entry			Eight Years After Entry		
	School 1	School 2	School 3	School 1	School 2	School 3
Cluster 1[b]						
Asian	39			69		
Black	35		38	54		44
Hispanic	26			34		
White	55	48	54	75	53	55
Foreign	65	49	62	75	52	64
Cluster 2						
Asian	34			55		
Black	30		27	41		33
Hispanic	22			27		
White	50	53	50	63	59	52
Foreign	59	46	58	65	46	58

[a]Estimates of candidacy and graduation rates are based on slightly different groups of students.

[b]Cluster 1 includes Mathematics, Physics, Computer Science, Economics, and Psychology. Cluster 2 includes Philosophy, History, English, Sociology, and Political Science.

Table 6. Estimated Percentage of Students Completing Ph.D. Degrees by Ethnic Group[a]

	Five Years After Entry			Eight Years After Entry		
	School 1	School 2	School 3	School 1	School 2	School 3
Cluster 1[b]						
Asian	7			59		
Black	6		1	54		7
Hispanic	2			27		
White	12	16	19	62	43	46
Foreign	23	23	36	68	39	61
Cluster 2						
Asian	1			40		
Black	1		0	32		1
Hispanic	1			5		
White	2	7	15	29	33	30
Foreign	5	5	27	44	13	39

[a]Estimates of candidacy and graduation rates are based on slightly different groups of students.

[b]Cluster 1 includes Mathematics, Physics, Computer Science, Economics, and Psychology. Cluster 2 includes Philosophy, History, English, Sociology, and Political Science.

Figure 1
Survival Analysis Results for Graduation: School 1, Cluster 1

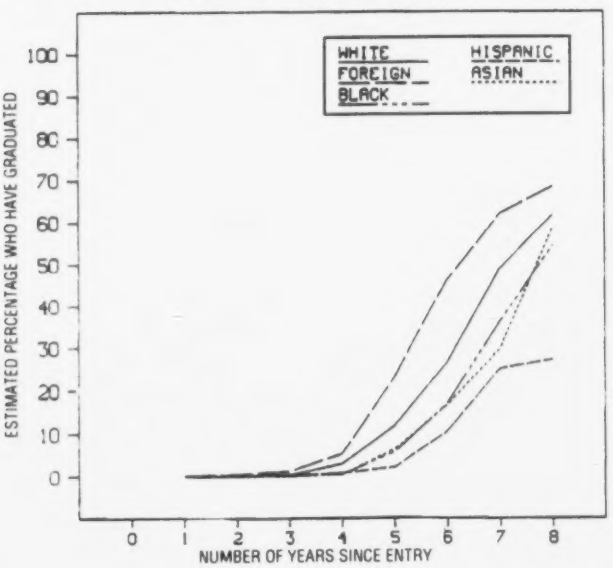


Figure 2
Survival Analysis Results for Graduation: School 1, Cluster 2

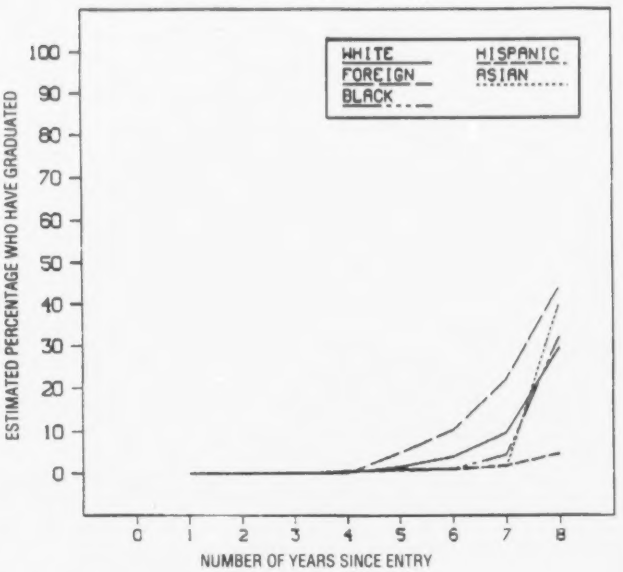


Figure 3
Survival Analysis Results for Graduation: School 2, Cluster 1

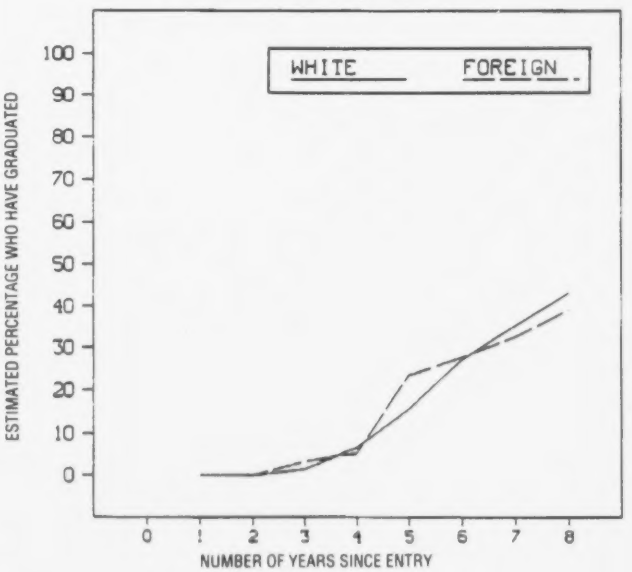


Figure 4
Survival Analysis Results for Graduation: School 2, Cluster 2

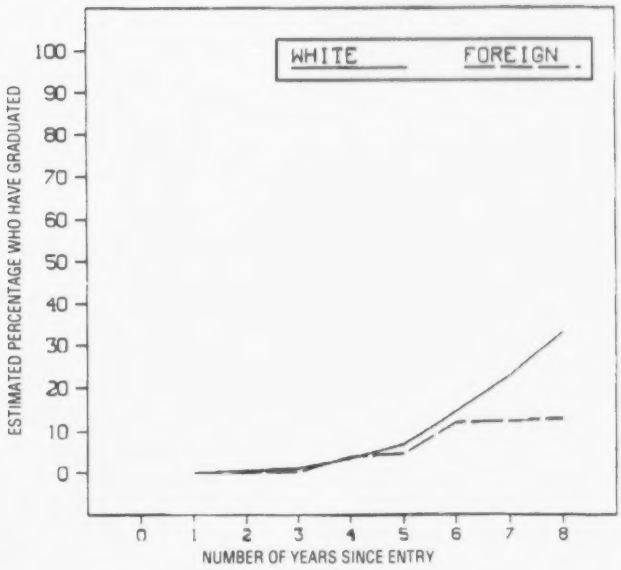


Figure 5
Survival Analysis Results for Graduation: School 3, Cluster 1

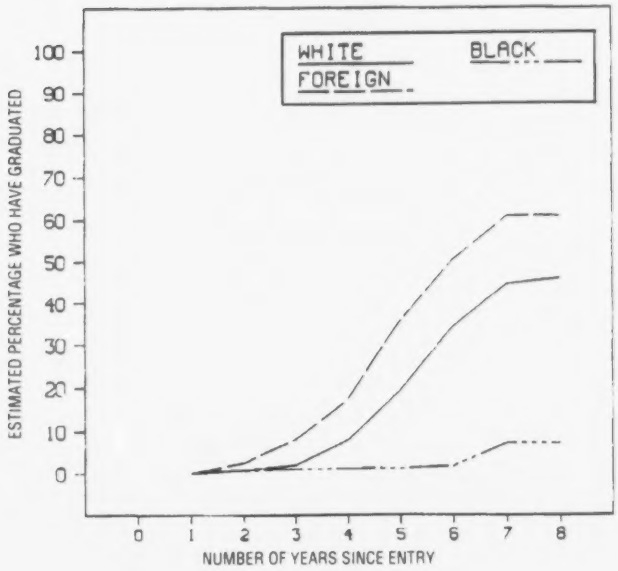
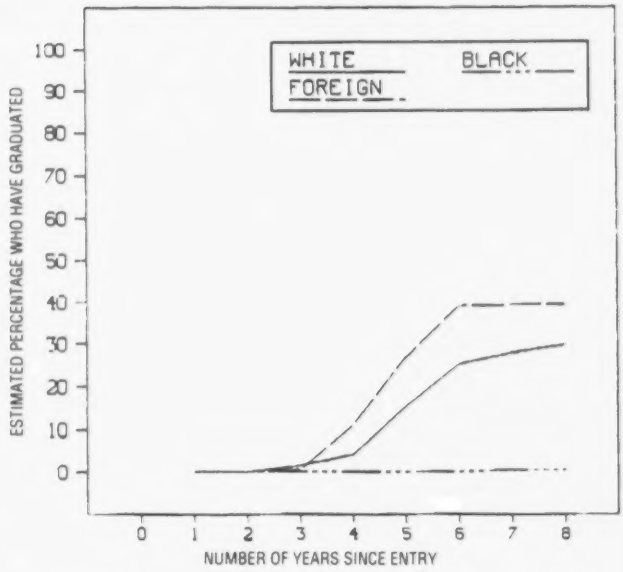


Figure 6
Survival Analysis Results for Graduation: School 3, Cluster 2



The plots for School 3 show the same ordering as the candidacy results; foreign students had the highest graduation rates, followed by White Americans; Black Americans had attainment rates equal to or close to zero. (Again, note that the results for Black students in Cluster 1 at School 3 are based on only seven students.) At School 1, the Cluster 1 results were similar to those obtained in the candidacy analysis, except that rates for Asian and Black students were virtually indistinguishable. In Cluster 2, all five groups were closer together, although graduation rates were clearly highest for foreign students and lowest for Hispanic students. At School 2, White and foreign students in Cluster 1 had similar attainment rates, as in the candidacy analysis; in Cluster 2, White students had substantially higher graduation rates than foreign students after year 6.

Gender Groups - Candidacy. Estimated percentages of students receiving candidacy five and eight years after entry are given in Table 7 for men and women in Clusters 1 and 2 at the three schools. In general, candidacy rates tended to be lower for women than men, although at School 3, the survival curves (not shown) were very close, particularly in Cluster 1. The differences between men and women in the percentage of students estimated to have achieved candidacy ranged from 0 to 13 percent at year 5 and from 1 to 6 percent at year 8. The most pronounced difference between men and women occurred in Cluster 2 at School 2 between years 5 and 8.

Gender Groups - Graduation. Estimated percentages of students completing Ph.D. degrees five and eight years after entry are given in Table 8 for men and women in Clusters 1 and 2 at the three schools. The results are similar to those obtained in the candidacy analysis in that attainment rates for men tended to be greater than those for women. Here, this pattern was evident for School 3 as well as the other two schools. Rates for men and women tended to be the most similar at School 1 and, again, the largest discrepancy occurred in Cluster 2 at School 2. The differences between men and women in estimated graduation rates ranged from 2 to 11 percent at year 5 and from 0 to 10 percent at year 8.

Table 7. Estimated Percentage of Students Achieving Ph.D. Candidacy by Gender Group[a]

	Five Years After Entry			Eight Years After Entry		
	School 1	School 2	School 3	School 1	School 2	School 3
Cluster 1[b]						
Men	58	48	56	75	52	58
Women	51	42	56	69	46	57
Cluster 2						
Men	53	56	52	64	59	52
Women	45	43	46	59	52	50

[a]Estimates of candidacy and graduation rates are based on slightly different groups of students.

[b]Cluster 1 includes Mathematics, Physics, Computer Science, Economics, and Psychology. Cluster 2 includes Philosophy, History, English, Sociology, and Political Science.

Table 8. Estimated Percentage of Students Completing Ph.D. Degrees by Gender Group[a]

	Five Years After Entry			Eight Years After Entry		
	School 1	School 2	School 3	School 1	School 2	School 3
Cluster 1[b]						
Men	15	20	26	65	40	52
Women	11	10	15	55	40	43
Cluster 2						
Men	3	10	20	36	32	33
Women	1	4	13	26	29	25

[a]Estimates of candidacy and graduation rates are based on slightly different groups of students.

[b]Cluster 1 includes Mathematics, Physics, Computer Science, Economics, and Psychology. Cluster 2 includes Philosophy, History, English, Sociology, and Political Science.

Relation of Candidacy and Graduation to Measures of Academic Potential

A correlational analysis, described below, was conducted to explore the association of candidacy and graduation with undergraduate grade-point average (UGPA), GRE verbal score (GREV), and GRE quantitative score (GREQ). (The percentage of students for whom GRE scores were available ranged from 75 to 100 across the 11 departments at the three schools. For UGPA, the percentages ranged from 44 to 95.) This analysis showed that GRE scores and UGPA were almost entirely unrelated to the achievement of candidacy and graduation.[5] Table 9 gives information on the association between graduation and candidacy, on one hand, and the three pre-admissions measures, UGPA, GREV, and GREQ, on the other. The table shows, for each school and each pair of variables, the 25th percentile, median, and 75th percentile of the distribution of point-biserial correlations for the 11 departments. (A point-biserial correlation is a Pearson correlation between a dichotomous variable and a continuous variable; see, e.g., Hulin, Drasgow, & Parsons, 1983.) The sample sizes on which these correlations are based averaged about 170 at School 1, 40 at School 2, and 50 at School 3.

In general, Table 9 shows that prediction was very poor, with median correlations ranging from -.09 to .15. UGPA and GREQ were somewhat more likely to be positively related to candidacy and graduation than GREV. Examination of the results for individual departments showed that the correlations between GREV and graduation that were largest in magnitude tended to be negative. The variations across departments in the size of the correlations did not appear to follow a consistent pattern. In general, prediction was best at School 3, followed by School 2, and then School 1.

Correlational analyses were also conducted within demographic groups. Within each of the three schools, correlations for the six pairs of variables in Table 9 were examined for foreign and White students and for men and women in Clusters 1 and 2. (Sample sizes were too small to permit examination of these correlations for ethnic minority groups.) Again, prediction was found to be poor.

[5]The candidacy variable was defined as follows: Individuals received a code of 1 if they attained candidacy within four years of entry and a code of 0 otherwise. That is, both dropouts and those who remained in school without attaining candidacy received a code of 0. Only students who had at least four years of opportunity to receive candidacy before the last recorded candidacy date were assigned values for this variable. The graduation variable was similarly constructed, except that students received a 1 if they graduated within six years of entry. These somewhat arbitrary cut-points were chosen to ensure that adequate numbers of students who did and did not attain the milestone in question were available for estimating the correlation.

Table 9. Summary Statistics: Correlations Between Milestone Attainment and Pre-admissions Measures for 11 Graduate Programs

Correlation	School 1			School 2			School 3		
	25th Percentile	Median	75th Percentile	25th Percentile	Median	75th Percentile	25th Percentile	Median	75th Percentile
Candidacy[a] with									
UGPA	.02	.08	.17	-.01	.15	.24	-.07	.11	.23
GREV	-.06	-.03	.09	-.19	-.02	.16	-.08	.03	.22
GREQ	.01	.09	.14	-.02	.10	.15	-.13	.09	.31
Graduation[b] with									
UGPA	.01	.04	.12	-.05	0	.27	-.06	.07	.23
GREV	-.19	-.01	.08	-.31	-.09	.05	-.22	-.06	.11
GREQ	-.10	.08	.12	-.10	0	.18	-.03	.11	.20

[a]The candidacy variable is equal to 1 for those who achieved candidacy within four years of entry and 0 otherwise. It is defined only for those with at least four years of opportunity.

[b]The graduation variable is equal to 1 for those who graduated within six years of entry and 0 otherwise. It is defined only for those with at least six years of opportunity.

These results show that, in the populations of Ph.D.-seeking students in these three schools, conventional measures of academic skills could not discriminate well between students who did and did not achieve candidacy and graduation. In evaluating these results, it is important to consider that it was not possible in this study to distinguish among several types of students who did not attain candidacy or graduation by the criterion date: those who were still in school, those who had temporarily left school, those who had withdrawn voluntarily, those who had been asked to withdraw for academic reasons, and those who had been asked to withdraw for nonacademic reasons. It may be, for example, that pre-admissions measures could have distinguished between those who completed degrees and those who were asked to withdraw for academic reasons.

In any case, the results do not imply that the GRE and UGPA were useless as admissions criteria: These graduate school matriculants had already been selected on the basis of GRE scores, UGPA, and other factors, and those with the least potential for achieving candidacy or graduation are likely to have been weeded out. From this perspective, then, the low correlations are not unexpected (see Dawes, 1975; Rubin, 1980). Similar results were reported by Zwick and Braun (1988) on the relation of UGPA and GRE scores to graduation and candidacy at Northwestern and by Zwick (1990) on the ability of UGPA and of scores on the Graduate Management Admission Test (GMAT) to predict graduation from doctoral programs in business and management.[6]

Within the select population of graduate students, it is likely that such personality factors as perseverance, as well as the availability of financial, social, and faculty support, play a crucial role in determining whether candidacy and graduation are achieved. In a study that included a student survey, Girves and Wemmerus (1988) found that involvement in the graduate program (e.g., participation in research projects, seminars, meetings, and social activities), student relationships with faculty, and financial support had a direct or indirect effect on progress toward the doctoral degree.

[6]In a summary of previously conducted studies of the relation between GRE scores and Ph.D. attainment, Willingham (1974) reported median correlations of .18 for GREV and .26 for GREQ. These results are not directly comparable to the present findings because the 47 correlations on which each median was based came from different institutions and corresponded to different administrative units.

SUMMARY AND DISCUSSION

Several types of analyses were conducted, based on nearly 5,000 Ph.D.-seeking students who matriculated in 11 departments at three large research universities between 1978 and 1985.

Descriptive analyses (combining across the 11 departments) showed that at all three schools, 72 to 75 percent of the students who entered between the fall of 1978 and the summer of 1981 were White Americans and 18 to 20 percent were foreign. The percentages of students who were Asian Americans, Black Americans, or Hispanic Americans summed to only 5 to 7 percent. For students who entered between fall of 1981 and fall of 1985, results at School 1 stayed essentially the same, while at the other two schools, the percentage of foreign students increased by about 10 and the percentage of White students decreased by the same amount. Results for the individual departments showed that most departments at School 2 and School 3, as well as the Computer Science and Sociology departments at School 1, experienced an increase in the percentage of foreign students and a decrease in the percentage of White students.

Examination of the proportions of men and women in graduate school showed that men outnumbered women by about 2 to 1 or more in each cohort at each of the three schools, combining across the 11 departments. At all three schools, the percentage of men was between 72 and 74 for students who entered between fall of 1978 and summer of 1981. (A Carnegie Commission study in 1968 yielded similar results for a sample of 80 universities [Feldman, 1974, p. 15].) For students who entered between fall of 1981 and fall of 1985, the percentages remained relatively steady at School 1 and School 3 but dropped to 65 percent at School 2. The percentage of men at all three schools was highest for foreign students, followed in order by Asian students, White students, Hispanic students, and Black students. Considering the data from all three schools, the most heavily male departments were Mathematics, Physics, and Computer Science, all of which were typically at least 80 percent male. The departments which came closest to having equal numbers of men and women were English, History, Psychology, and Sociology.

Survival analysis methods were used to study the rates of candidacy and graduation for the eight years following students' entry into graduate school. First, analyses were conducted by department. For purposes of display and discussion, departments were divided into three groups. In general, the Group I departments, Chemistry, Physics, Mathematics, and Computer Science, had higher rates of candidacy and graduation than the Group III departments, Psychology, Political Science, Sociology, and Economics, which in turn had higher attainment rates than the Group II departments, English, Philosophy, and History.

Only at School 1 were at least 50 percent of students in all 11 departments estimated to have achieved candidacy by year 8. In about half the departments at School 1 and most departments at the two other schools, the estimated percentage of students graduating by year 8 was less than 50.

Survival analyses were also conducted for ethnic and gender groups. A finding that was generally consistent for Schools 1 and 3 was that candidacy and graduation rates were higher for foreign students than for White Americans and higher for White Americans than for Black Americans. Results from School 1 showed that Asian and Hispanic Americans also tended to have lower attainment rates than White students.

Because survival analysis allows examination of candidacy and graduation rates at multiple time points, it gives a more detailed picture of milestone attainment than simple rates of candidacy or graduation. Analyses of this type may be useful to graduate school deans in estimating the number of graduates an entering class is likely to yield and in determining whether administrative changes are needed to hasten progress in some departments or whether special programs are needed to encourage the persistence of some groups of students.

The well-documented scarcity of Black Americans and other minority group members enrolling in U.S. graduate schools (ACE, 1987; ACE/ECS, 1988; Blackwell, 1987; Brown, 1987; Mooney, 1989; Trent & Copeland, 1987) was strikingly evident in the three schools in this study. Also, the candidacy and graduation rates of Asian, Black, and Hispanic Americans were lower than those of White Americans and foreign students. What accounts for the low participation rates of minority students in graduate education? One of the most commonly mentioned possible reasons is the lack of adequate financial resources (Blackwell, 1987; Mooney, 1989; National Board of Graduate Education, 1976; Nettles, 1987; Pruitt & Isaac, 1985; Thomas, 1987). Another possible factor is the attraction of professional schools (Chamberlain, 1988; Mooney, 1989; Pruitt & Isaac, 1985), although Nettles (1987) and Thomas (1987) concluded that this speculation was unsupported. Some researchers have cited discrimination in the recruitment and admissions process (Pruitt & Isaac, 1985), the perceived "inhospitality of academe" (Mooney, 1989), and the lack of adequate support services and opportunities for faculty mentoring of minority students. Finally, some sources (Astin, 1982; Blackwell, 1987; National Board of Graduate Education, 1976) have stressed the need for increased support for minority students earlier in the educational pipeline. A 1988 ACE/ECS report states,

> The aptitude for higher education and the ability to succeed in college and graduate school do not materialize suddenly at age 18; they are developed in childhood. Currently, we lose disproportionate numbers of minority students at each level of schooling, culminating in low participation rates in higher education. Only through intense, coordinated efforts at every stage — beginning with adequate prenatal care, improved nutrition, and quality child care and extending through programs to increase minority retention and improve student performance at the elementary and secondary levels — can we hope to reverse these dismal trends. (p. 14)

Another finding of the current study was that, at Schools 1 and 3, foreign students had higher candidacy and graduation rates than American students. There are several possible reasons for these higher rates. Foreign students are likely to have been

selected to study in the United States because of their academic excellence. Girves and Wemmerus (1988, p. 169) speculated that "the fact that foreign students must be enrolled full-time and must demonstrate sufficient financial support to carry out their degree programs may be more incentive for them to complete their degrees. Domestic students, on the other hand, do not necessarily have these incentives, and may have other options outside of graduate school." It is not clear why the pattern at School 2, where White students had rates that equalled or exceeded those of foreign students, differed from that observed at School 1 and School 3.

In general, both candidacy and graduation rates tended to be higher for men than for women. Earlier studies have also found that women enrolled in doctoral programs are less likely to attain the degree than their male counterparts (see Feldman, 1974; Patterson & Sells, 1973). Some of the reasons cited for the lower proportions of women in graduate school and their lower attainment rates are analogous to those offered in discussing the participation of ethnic minorities in graduate school; for example, discrimination in admissions, in counseling (Roby, 1973), and in the distribution of financial aid (Chamberlain, 1988), and an inhospitable campus climate (Chamberlain, 1988; Feldman, 1974; Schwartz & Lever, 1973). Berg and Ferber (1983) and Feldman (1974) cited the scarcity of female mentors in graduate school, along with the finding that women were less likely than men to establish close working relationships with male faculty members. In discussing the higher dropout rates for women in graduate programs in science and engineering, Widnall (1988) cited lack of self-esteem, feelings of alienation, poor relationships with faculty advisors, and discrimination as possible reasons. Women may also be less likely than men to perceive the completion of school as an economic necessity, as Tinto (1975) noted with regard to undergraduate education. It may also be true that women are more likely than men to take reduced course loads or to leave school because of family responsibilities.

Examination of GRE and UGPA data for ethnic and gender groups showed that group attainment rates were not, in general, ordered in the same way as group means on the pre-admissions measures. For example, at School 1 in both clusters, White students had roughly the same GREQ and UGPA means as foreign students and had GREV means that were about 150 points higher, yet foreign students had higher attainment rates. Similarly, Hispanic students in School 1 tended to have higher means than Black students on the pre-admissions measures, but had lower attainment rates.

Finally, more formal analyses were conducted to examine the relation between candidacy and graduation, on one hand, and pre-admissions measures of academic skills on the other. These correlational analyses also showed little or no relation between attainment rates and UGPA or GRE scores. This finding is not entirely unexpected, given that graduate students have been selected using these measures. Within this very competent group of people, it is likely that nonacademic measures determine who will succeed.

It is important to note that all three universities in this study have selective and prestigious graduate schools. Therefore, the research results cannot be assumed to be widely generalizable. However, it is hoped that the findings will be useful to the participating schools, will serve to illustrate the types of analyses that can be informative to graduate school policy makers, and will suggest hypotheses that can be investigated for larger groups of institutions.

REFERENCES

American Council on Education. (1987). *Minorities in higher education.* Washington, DC: Author.

American Council on Education/Education Commission of the States. (1988). *One third of a nation: A report of the commission on minority participation in education and American life.* Washington, DC: American Council on Education.

Astin, A. W. (1982). *Minorities in American higher education.* San Francisco: Jossey-Bass.

Berg, H. M., & Ferber, M. A. (1983). Men and women graduate students: Who succeeds and why? *Journal of Higher Education, 54,* 629-648.

Blackwell, J. E. (1987). *Mainstreaming outsiders: The production of black professionals* (2nd ed.). Dix Hills, NY: General Hall.

Brademas, J. (1984). Graduate education: Signs of trouble. *Science, 223,* 881.

Braun, H. I. (1985). *Bayesian analysis of families of survival curves.* Unpublished manuscript, Educational Testing Service.

Braun, H. I., & Zwick, R. (1989). *Bayesian analysis of families of survival curves: Applications to the analysis of degree attainment.* Unpublished manuscript, Educational Testing Service.

Brown, S. V. (1987). *Minorities in the graduate education pipeline.* (A research report of the Minority Graduate Education project, jointly sponsored by the GREB and ETS.) Princeton, NJ: Educational Testing Service.

Chamberlain, M. K. (Ed.). (.1988). *Women in academe: Progress and prospects.* New York: Russell Sage Foundation.

Dawes, R. M. (1975). Graduate admissions variables and future success. *Science, 187,* 721-723.

Feldman, S. D. (1974). *Escape from the doll's house: Women in graduate and professional school education.* New York: McGraw-Hill.

Girves, J. E., & Wemmerus, V. (1988). Developing models of graduate student progress. *Journal of Higher Education, 59,* 163-189.

Hartnett, R. T. (1987). Has there been a graduate student "brain drain" in the arts and sciences? *Journal of Higher Education, 58,* 562-585.

Hulin, C. L., Drasgow, F., & Parsons, C. K. (1983). *Item response theory: Application to psychological measurement.* Homewood, IL: Dow Jones-Irwin.

Mathematical Methods in Educational Research, School of Education, Stanford University. (1983). *A survival analysis of "Time-to-Ph.D." data for selected departments of Stanford University.* Report to Gerald R. Lieberman, Dean of Graduate Studies, Stanford University.

Mooney, C. J. (1989). Affirmative-action goals, coupled with tiny number of minority Ph.D.'s, set off faculty recruiting frenzy. *The Chronicle of Higher Education, 35,* 1, 10-11.

Murnane, R. J., Singer, J. D., & Willett, J. B. (1988). The career paths of teachers: Implications for teacher supply and methodological lessons for research. *Educational Researcher, 17,* 22-30.

National Board on Graduate Education. (1976). *Minority group participation in graduate education.* Washington, DC: National Academy of Sciences.

National Research Council. (1986). Summary report 1984: *Doctorate recipients from United States universities.* Washington, DC: National Academic Press.

Nettles, M. (1987). *Financial aid and minority participation in graduate education.* (A research report of the Minority Graduate Education [MGE] Project, jointly sponsored by the Graduate Record Examinations Board and Educational Testing Service.) Princeton, NJ: Educational Testing Service.

Patterson, M., & Sells, L. (1973). Women dropouts from higher education. In A. S. Rossi & A. Calderwood (Eds.), *Academic women on the move* (pp. 79-91). New York: Russell Sage Foundation.

Pruitt, A. S., & Isaac, P. D. (1985). Discrimination in recruitment, admission, and retention of minority graduate students. *Journal of Negro Education, 54,* 526-536.

Roby, P. (1973). Institutional barriers to women students in higher education. In A. S. Rossi & A. Calderwood (Eds.), *Academic women on the move* (pp. 37-56). New York: Russell Sage Foundation.

Rubin, D. B. (1980). Using empirical Bayes techniques in the law school validity studies. *Journal of the American Statistical Association, 75,* 801-816.

Schwartz, P., & Lever, J. (1973). Women in the male world of higher education. In A. S. Rossi & A. Calderwood (Eds.), *Academic women on the move* (pp. 57-77). New York: Russell Sage Foundation.

Thomas, G. E. (1987). Black students in U.S. graduate and professional schools in the 1980's: A national and institutional assessment. *Harvard Educational Review, 57,* 261-282.

BEST COPY AVAILABLE

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research, 45,* 89-125.

Trent, W. T., & Copeland, E. J. (1987). *Effectiveness of state financial aid in the production of Black doctoral recipients.* Atlanta: Southern Education Foundation.

Widnall, S. E. (1988). AAAS presidential lecture: Voices from the pipeline. *Science, 241,* 1740-1745.

Willingham, W. W. (1974). Predicting success in graduate education. *Science, 183,* 273-278.

Zwick, R. (in press). *Analysis of graduate school careers in three universities: Differences in attainment patterns across academic programs and demographic groups.* GRE Research Report series.

Zwick, R. (1990). *The validity of the GMAT for the prediction of success in doctoral study in business and management.* ETS Research Report 90-24. Princeton, NJ: Educational Testing Service.

Zwick, R., & Braun, H. I. (1988). *Methods for analyzing the attainment of graduate school milestones: A case study.* (GRE Board Professional Report 86-3P, ETS Research Report 88-30.) Princeton, NJ: Educational Testing Service.

54018-01134 • Y31M20 • 209955